4aPPb27. Can monaural temporal masking asymmetry explain the transient and/or ongoing precedence effect?

Richard L. Freyman*, Charlotte Morse-Fortier, Amanda M. Griffin and Patrick M. Zurek

*Corresponding author’s address: Department of Communication Disorders, University of Massachusetts, 358 N. Pleasant St., Amherst, MA 01003, rlf@comdis.umass.edu

Investigations of the precedence effect show that interaural differences within the first of two pairs of brief binaural sounds contribute more to lateralization than those within the second pair. The present study asked whether this phenomenon could be explained by asymmetries in monaural masking, and compared the results to a second experiment investigating the same question with the ‘ongoing’ precedence effect. Leading and lagging stimuli were binaural pairs of 1 ms frozen noise bursts, with a 2 ms delay between pairs, and had ITDs of +500 and -500 microseconds respectively. Detection thresholds for lead or lag in the presence of the other were assessed monaurally using a 4AFC task. Results showed that threshold for the lead was 12 dB better than that for the lag, on average. Ongoing stimuli were created by repeating the transient stimuli 63 times, with a new noise token on each repeat. Although the leading burst in each binaural pair contributes more to lateralization than the lagging burst, monaural thresholds for the leading bursts were not better than those for the lagging bursts. The results suggest that the transient precedence effect, but not the ongoing precedence effect, might be explained by temporal masking asymmetry [Supported by NIH DC01625].

Published by the Acoustical Society of America through the American Institute of Physics
INTRODUCTION

The lateralization of stimuli consisting of two pairs of brief binaural pairs of sounds is controlled largely by the interaural differences in the first of the two pairs, a phenomenon known as the precedence effect. Proposed explanations for the precedence effect include central inhibitory processes (Lindemann, 1986a,b) as well as more peripheral mechanisms that depend on adaptation at the cochlear level (Hartung and Trahiotis, 2001). Consistent with hypotheses based on peripheral contributions, Gaskell and Henning (1999) demonstrated strongly asymmetric monaural masking for pairs of brief sounds, with an initial pulse (the lead sound) producing more forward masking on a second pulse (the lag sound) compared with the backward masking produced by the lag on the lead. The implication of these asymmetric masking results is that the response to the second pulse is not as strong as it is to the first pulse when the two are presented at equal levels. Therefore, the second pulse produces a weaker input to more central processing stages of a binaural model.

In our lab we have been studying the precedence effect for longer trains of noise bursts, depicted schematically in Figure 1. Essentially, the stimuli used to demonstrate the precedence effect for brief sounds are repeated without interruption for a total of 250 ms. One-ms noise bursts are used instead of pulses, and the sample of noise is changed after each two-pair sequence, indicated by the numbers inside the burst envelopes. Several manipulations of these stimuli have shown that their lateralization is dominated by the interaural time delay (ITD) of the first instance of each token, and is not dependent on the ITD within the very first burst pair of the train (Freyman, Balakrishnan, and Zurek, 2010). This phenomenon is called the “ongoing” precedence effect. The purpose of the current study was to determine whether masking asymmetry between the first (lead) and second (lag) instance of each token could potentially explain the ongoing precedence effect. Two main experimental conditions were tested. The first studied monaural temporal masking asymmetry for the two-pair transient stimulus, a partial replication of Gaskell and Henning (1999) but with noise-burst stimuli, in order to verify that our procedures and stimuli would produce similar results. The second, entirely new, condition repeated this experiment for the ongoing 250-ms noise burst trains.

METHODS

Listeners were two female graduate students, age 27, with hearing thresholds \(\leq 20\) dB HL at audiometric frequencies from 250-8000 Hz.

Stimuli were derived from those shown in Figure 1, except that the presentation was always monaural. Both top and bottom channels were tested in separate conditions. The transient type of stimulus (Figure 2) consisted of just one two-pair sequence. Only the 2.5-ms onset-to-onset delay condition is shown in the figure, taken from the bottom channel in Figure 1. The 1.5-ms condition, derived from the top channel in Figure 1, was also tested. The signal to be detected was either the lag (left drawing in Figure 2) or lead (right drawing in Figure 2), and was varied in level across blocks in the presence of the fixed-level masker. The masker alone was presented in three of the four intervals of a four-alternative-forced-choice (4AFC) trial, while the fourth, randomly selected interval contained both the signal and masker. Correct-answer feedback was provided on each trial. The signal-to-masker ratio, SMR, was fixed within a block of 25 trials. The first five trials in each block were discarded, so that each block trial contained 20 experimental trials. Four blocks were obtained at each SMR for a total of 80 trials per data point. Preliminary testing was conducted with both subjects to determine the appropriate SMRs. The preliminary testing was extensive and also served as practice.
FIGURE 2. Stimuli used to test masked detection of lead and lag transient signals. The signal to be detected is indicated by yellow shading. The example shown indicates an SMR of -6 dB.

For the ongoing stimuli (Figure 3), the signal consisted of all the lag (top) or lead (bottom) bursts, and all were attenuated to the same degree. The masker consisted of just the lead (top) or lag (bottom) bursts, and was presented alone in three of the four intervals of the 4AFC trial. The signal was added to the masker in the fourth randomly-selected interval. Testing procedures were identical to those used for the transient stimuli.

FIGURE 1. Stimuli used to test masked detection of lead and lag signals for ongoing trains. The signal to be detected is indicated by yellow shading. The example shown indicates an SMR of -6 dB.

Stimuli were generated on a personal computer with a 24-bit sound card, low-pass filtered at 8.5 kHz, attenuated (TDT PA4), and delivered monaurally through a TDH 39 headphone (right headphone) via a headphone amplifier (TDT HB5) and a passive attenuator at a level of 70 and 84 dB SPL for the ongoing and transient stimuli, respectively.

RESULTS

Results from one subject who has completed data collection are plotted below in Figure 4. Data are shown for the 2.5 ms delay for both the transient and ongoing stimuli depicted in Figures 2 and 3.

FIGURE 4. Percent correct detection as a function of SMR for transient and ongoing stimuli for one subject. For the transient stimuli (dashed lines), threshold was approximately 12 dB better in the lead condition than the lag condition at the 71% correct point. No such shift was observed for the ongoing stimuli (solid lines).
For the transient stimuli, better performance was observed in the lead-detection condition than in lag-detection. There was approximately a 12 dB improvement in SMR for the lead relative to the lag condition at the 71% correct point. For ongoing stimuli, performance was much more similar between lead and lag conditions. In fact, lag-detection performance was slightly better than lead-detection at some SMRs (e.g. -12 and -14 dB). There was approximately a 1-dB difference in SMR between lag and lead conditions at the 71% correct point. Similar trends in results were obtained in the preliminary data from the other subject and from the 1.5-ms delay conditions.

DISCUSSION

The results are considered as they relate to potential explanations for the precedence effect that depend on differences in the strength of monaural processing of lead and lag signals. Significant temporal masking asymmetries were observed for pairs of brief monaural noise bursts. Forward masking was at least 10 dB more effective than backward masking for burst onset-to-onset delays of 1.5 ms (not shown) and 2.5 ms (Figure 4). These values are comparable to the masking asymmetries observed by Gaskell and Henning (1999). This result indicates that the lag burst is at a lower sensation level than the lead burst when the two are presented at equal levels in the classic precedence effect paradigm. With the current data, it cannot be determined whether the lower sensation levels translate into reduced internal representation in a manner that could explain the precedence effect. However, as Gaskell and Henning (1999) concluded, this masking asymmetry cannot be excluded as a basis for the precedence effect for transient stimuli.

The same cannot be said for 250-ms trains of alternating lead and lag bursts. If confirmed with the full set of data, the results obtained for these stimuli will indicate that there is no masking asymmetry in favor of detection of lead bursts relative to the lag bursts. Indeed a slight trend in the opposite direction was observed. Therefore, the ongoing precedence effect is unlikely to be accounted for by monaural masking processes.

ACKNOWLEDGMENTS

The authors are grateful to the National Institute on Deafness and Other Communication Disorders for its support of this research (DC 01625).

REFERENCES


